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SUPPORT MODEL

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# WEAPON SYSTEM SPARES

# SUPPORT MODEL

A School of Systems and Logistics AU-AFIT-LS Technical Report


Air University

Air Force Institute of Technology

Wright-Patterson AFB, Ohio

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This paper presents an aircraft weapon system spares support model for determining the number of days of contingency operations which are supportable. Contingency spares support is of paramount concern to Air Force readiness. The translation of current or predicted inventory positions into meaningful measures of military capability is crucial to both operational and logistics planning. Currently the Air Force has no management information system which can accurately assess spares support for its deployable weapon systems. The authors have developed a practical interim planning structure and preliminary decision support model which provides for mid to long-range (i.e., 3-10 years) spares readiness assessment.

## ABSTRACT


This paper presents an aircraft weapon system spares support model for determining the number of days of contingency operations which are supportable. Contingency spares support is of paramount concern to Air Force readiness. The translation of current or predicted inventory positions into meaningful measures of military capability is crucial to both operational and logistics planning. Currently the Air Force has no management information system which can accurately assess spares support for its deployable weapon systems. The authors have developed a practical interim planning structure and preliminary decision support model which provides for mid to long-range (i.e., 3-10 years) spares readiness assessment.

# Introduction

Today, national defense is the slave of sophisticated technology and costly spare parts are particularly critical. In the case of the aircraft component of our national defense, the availability of spare parts might even be called the Achilles' heel of modern warfare. These items are the essential non-consumable repair parts whose failure are critical to the combat capability of our modern aircraft weapon systems.

Although the Air Force has reliable management systems for tracking consumable materials such as petroleum and ammunition, there remains an information vacuum for decision support in the area of non-consumable or reparable items. In 1975 these reparables amounted to some 1.9 million line items worth over nine billion dollars. The inventory management decisions involved are directly related to a reasonable determination of military capability and readiness. In the context of a rapid deployment force, planners and policy makers need the capability to translate both peacetime training and war reserve spare assets into a measure of combat surge capability. Clearly, inventory position is not the sole determinant of military capability, but it is equally clear that over a very short interval, spares will become a limiting constraint [3].

A finite determination of the limitations of spare support is

presently beyond the information capability of logistics planners and current data systems. Such an effort would involve maintaining historical data on hundreds of thousands of items, many of which would be used on several different aircraft with differing failure rates. The development and maintenance of such a data base may one day feed a decision support system which will allow the needed analysis. Such an effort will be time consuming and expensive; moreover, there is the ominous problem of dealing with the present. The Air Force is constrained by an austere procurement/support environment which necessitates maximum benefit acuity in dollar allocation.

## Solution Approach

What the Air Force felt it needed was a reasonably accurate method for obtaining a "best estimate" command/planning indicator for spares supportability. The recommended method should be simple, fast, and inexpensive. Fortunately, much of the data gathering required to develop such a model had already been accomplished. Standard requirements for combat operations and spares levels may be derived from war planning and program documents available to the researchers. From the available information a planning model was developed to estimate total contingency spares supportability for discrete aircraft systems. The model can be simply stated as:

$$y = \omega + Fx(\varepsilon) \qquad (1)$$

where,

$y$ = total days of spares support available

$\omega$ = the number of war days spares support

available from war reserve materials

x = number of planned days of contingency operations (war days)

$\varepsilon$ = the inherent variability due to degradation of actual peacetime support

F = $F_p/F_w$; proportion of programmed flying hours in a standard peacetime day to the number of programmed flying hours in a planned war day (varies among planned operations)

In any given contingency, spares support comes from two sources: war reserve materials and peacetime flying program inventory assets. Reserve materials are currently programmed to provide up to thirty days of spares support and the peacetime flying program provides a measure of spares support which can be expressed as a ratio of the wartime flying requirement. When these quantities are added together, they provide the total spares asset availability for a given weapon system for a contingency. The contingency plan defines the required period of support and the levels of weapon system activity. If the total spares assets available to support the contingency are equal to or are greater than the requirement, the contingency has a high probability of supportability. Conversely, when the requirement is greater than the asset availability, the contingency plan has a poor probability of supportability. The balance of this paper undertakes the substantiation and improvement of the components of the model to demonstrate its applicability as a planning tool for predicting contingency spares support.

This paper will analyze the validity and applicability of the spares supportability model by focusing on two basic components

of Eq 1. It is understood that variable values may differ when applied to different weapon systems.

1. How many days of support can planners expect to realize from the designated war reserve materials?

2. What support degradation can be expected in the peacetime flying program due to lack of spare parts?

Each component has been statistically analyzed based on historical data from representative weapon systems to demonstrate applicability. The analysis of the equation components provide the empirical basis for developing planner confidence in the predictive accuracy of the model.

The spares considered in this research were primarily recoverable items--items that can be repaired by maintenance activities at base or depot when unserviceable, and reissued. These items are distinguished from end items which do not become part of a larger operating system when in use, nor lose their identity. Further, these items are distinguished from EOQ items which are obtained on a consumption basis and thrown away when they become inoperable. From the management and budgeting standpoints respectively, reparables are the most complex and expensive items. Furthermore, our attention, with respect to war reserve materials, is primarily focused upon those assets which are transportable as integral to the total deployment package during contingency operations. With respect to $\omega$, the expected number of days of spares support available from reserve materials, the goal was to locate a lower bound for the number of

war days which can be supported with 95 percent confidence.

## Reserve Materials

The Air Force planning standard for $\omega$ has been set at thirty days since this is a common contingency senario planning horizon for deployments. In reality, the day-to-day fill rates for these assets seldom achieve the 30 day standard. This asset shortfall results primarily from overall asset shortages associated with budgetary decisions that have necessitated the practice of drawing from reserves to meet priority peacetime commitments. The amount of degradation in reserve asset levels would be expected to vary by weapon system, but each day's shortfall in reserves may translate into unmet operational commitments during a contingency.

Since the level of reserve assets affects a unit's contingency capability, the Air Force routinely collects monthly data indicating asset levels. Since some gaming of this data is possible and it is a recognized indicator of combat readiness, a conservative approach was taken by determining the lower bound for the number of war days which can be supported with 95 percent confidence.

A sample population of 114 units each having three years of historical data was identified. Fifteen composite (mean) random samples were derived for each year. Since the percent of asset fill is highly skewed, averaging simple random samples ensures an approximately normal distribution. The composite sample data is shown in Table [illegible] classification restrictions, actual years and weapon systems [illegible]

[illegible] mean percent fill rate of [illegible] Using a chi-square

TABLE 1

Percent Fill of War Reserve Materials

| | | | | |
|---|---|---|---|---|
| 1. | Year #1 | 96.6 | 95.2 | 94.0 |
| | | 90.8 | 96.0 | 86.8 |
| | | 95.2 | 93.0 | 88.8 |
| | | 87.6 | 96.0 | 95.8 |
| | | 94.0 | 99.0 | 92.6 |
| 2. | Year #2 | 95.6 | 96.6 | 89.8 |
| | | 93.2 | 84.6 | 94.8 |
| | | 96.4 | 92.0 | 91.3 |
| | | 93.7 | 93.6 | 93.8 |
| | | 91.6 | 96.8 | 91.6 |
| 3. | Year #3 | 98.6 | 95.0 | 92.2 |
| | | 93.8 | 97.2 | 96.6 |
| | | 95.6 | 94.6 | 92.8 |
| | | 93.0 | 86.2 | 93.4 |
| | | 93.4 | 93.9 | 89.0 |

$\bar{x} = 93.904$ $\sigma_{\bar{x}} = 3.0692$

test ($\alpha$ = .01) it was shown that the sample population is normally distributed.

Provided that the selected units comprising a contingency deployment force are members of this normal population, it follows that by employing the unbiased estimators for mean and standard deviation a 95 percent confidence internal for reserve asset fill rate for contingency forces can be constructed [18:368].

$$\bar{x} \pm \gamma_{.95}(\sigma_{\bar{x}})$$

$$93.9 \pm 1.645\ (3.0692)$$

$$93.9 \pm 5.05$$

or

$$88.85 \leq \text{expected reserves fill rate} \leq 98.95$$

Therefore, a conservative interpretation of applicable empirical data suggests that planners can expect at least an 88.85 percent fill rate for war reserve materials. Since the programmed levels would provide sufficient assets to support 30 days of operation, this information suggests planners should more realistically expect that a given task force's reserve assets will likely only last 26.66 days.

Thus, our model (EQ 1) can be more precisely restated as

$$y = 26.66 + FX(\varepsilon) \qquad (2)$$

The value of $\omega$ is dependent upon budgetary, procurement, and weapon system operation levels. Periodic analysis of the fill rates is

needed to insure the inclusion of the appropriate variable value in the model.

For analytical purposes, it was assumed that percent war reserve fill was a direct measure/indication of the percent of support capability. Unfortunately, there exists the inherent possibility of inaccuracy of data reporting. This is particularly true because of constant pressure on unit commanders to both maintain reserve materials in a high state of readiness and high performance demands in peacetime flying operations. One of the characteristics of current Air Force supply procedures is that war reserve assets are used to augment and support daily peacetime flying operations. Hence, the most critical operational items are likely to be those taken from reserves. Pressures to maintain high standards of readiness could cause commanders to overestimate the support capability of their unit's reserves. Hence, there is not necessarily a direct relationship between percent fill and mission capability. Percent fill is, however, the best empirical indicator available to indicate readiness in a quantitative manner; however, if the items missing are high failure/hard to replace/short supply items, as is likely to be the case, it is possible that the percent missing would have greater adverse impact than otherwise indicated in determining reserve materials readiness. In order to overcome this, each Air Force unit commander provides a subjective analysis of unit reserves to determine an appropriate readiness rating, but the relationship should not be construed to be exact. For this reason, a binomial analysis was conducted using the commander supplied combat readiness ratings

for the same sample as defined above.

The binomial analysis yielded evidence which supported the use of the more conservative lower bound 95 percent confidence interval. Although the mean war reserve percent fill was almost 94 percent, which indicated expected spares support to be twenty-eight war days, the lower bound was chosen as the baseline because it represented the at-least-quantity expected to be available. Hence, the baseline selected was a conservative estimate. It should be noted that twenty-seven is 90 percent of thirty, which indicates possible degradation of 10 percent. This corresponds to the condescriptive degradation analysis conducted. Interestingly, the lower bound of the 95 percent confidence level, i.e., 88.85 percent is extremely close to the expected war reserves percent fill subsequent to 10 percent degradation due to gaming, high failure items, reporting inaccuracy, etc., i.e., 88.22 percent. Further investigation would be required to substantiate a direct relationship; however, it is possible that the lower bound of the confidence interval absorbs both inaccuracies inherent in reserve material readiness.

It is not anticipated that the factor (twenty-seven days of spares support) precisely depicts actual reserves readiness. It is, however, a better indication of readiness than the assumed factor of thirty. It is anticipated that actual testing will substantiate this claim. Unfortunately, such testing is expensive and conducted infrequently. One method for testing actual war reserves degradation is actual deployment. Upon deployment, however, management options are usually limited. Further, during deployment control factors are usually obscured by the necessity for swift action.

If would appear that the most feasible method of determining reserves support is via computer simulation. Such a model was developed by Rasmussen and Stover [10]. Simulation runs indicated that for the RF-4C aircraft, significant shortages were encountered after day twenty-eight of deployment. This clearly supports the statistical analysis conducted herein.

## Peacetime Assets

Our attention now turns to an analysis of what level of support can actually be expected from the peacetime flying program assets. Again, the analysts were fortunate in that the Air Force maintains a data base of day-to-day operational status. The data base reflects, among other things, when a weapon system is either degraded or fully incapable of performing due to lack of adequate spares support. By selecting an appropriate sample, we can develop an estimator of peacetime support degradation for the logistics planning model.

In selecting an appropriate sample, it was decided to limit it to weapon systems which will typically be deployed during tactical contingencies, and since overseas units would certainly be expected to participate, they should be represented in the sample. The sample was limited to two aircraft (i.e., F-4 fighter and C-130 transport). Four combat ready units were selected for each aircraft with two of each stationed in the United States and two in foreign locations. Four years of monthly data was collected representing the combined percentage of degraded and incapable system time chargeable to lack of adequate spares support. The monthly average

of this data was computed and is displayed in Table 2.

Statistical analysis yielded a mean degradation rate of 5.93 percent with a standard deviation of 1.3068. Using a chi-square test ($\alpha = .01$) it was shown that the sample population was normally distributed.

Using the empirically derived unbiased estimators of mean and standard deviation, a conservative 95 percent confidence interval for peacetime spare asset degradation can be constructed [18:368].

$$\bar{x} \pm \gamma_{.95} (\alpha_{\bar{x}})$$

$$5.93 \pm 1.645 \ (1.3068)$$

$$5.93 \pm 2.1497$$

or,

$$3.78 \leq \begin{matrix}\text{peacetime spare} \\ \text{degradation rate}\end{matrix} \leq 8.08$$

Therefore, a conservative interpretation suggests the percent of weapon system degradation due to spare assets will be less than or equal to 8.08 percent. This upper bound of expected system degradation can also be interpreted as determining the lower bound of peacetime spares support expected with 95 percent confidence.

$$1 - .0808 = .9192$$

Thus, approximately 92 percent of the peacetime flying program is being supported. If the variance of peacetime spares degradation is constant for different aircraft at different bases (i.e., if the

TABLE 2

Peacetime Asset Degradation
(mean composite date 1976-1979)

| A/C | Base | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F-4 | Clark, Philipines | 6.45 | 6.53 | 6.80 | 6.75 | 7.25 | 5.25 | 6.88 | 5.48 | 4.85 | 5.08 | 3.42 | 7.07 |
| | Ramstein, Germany | 6.69 | 5.97 | 6.43 | 4.72 | 4.58 | 5.87 | 4.98 | 6.85 | 4.98 | 5.95 | 6.65 | 6.82 |
| | George, Calif. | 5.35 | 6.32 | 6.43 | 5.45 | 6.62 | 5.28 | 6.75 | 7.08 | 6.48 | 4.72 | 6.32 | 5.67 |
| | Homestead, Fla. | 4.65 | 5.03 | 4.88 | 5.52 | 6.28 | 6.35 | 5.13 | 7.10 | 6.51 | 6.42 | 6.80 | 5.82 |
| C-130 | Kadena, Okinawa | 5.15 | 8.90 | 8.40 | 7.03 | 5.08 | 6.50 | 3.11 | 6.18 | 5.33 | 2.23 | 6.02 | 5.87 |
| | Rheinmain, Germany | 6.60 | 8.36 | 5.07 | 8.52 | 8.35 | 4.76 | 3.57 | 6.13 | 5.05 | 5.83 | 5.15 | 5.35 |
| | Selfridge, Mich. | 3.43 | 5.65 | 7.23 | 5.50 | 5.65 | 5.97 | 6.47 | 6.88 | 4.70 | 5.57 | 8.43 | 6.42 |
| | McClellan, Calif. | 8.00 | 8.02 | 8.30 | 4.31 | 6.78 | 5.17 | 3.90 | 3.62 | 4.65 | 4.88 | 5.13 | 6.08 |

$\bar{x} = 5.93$ $\sigma_{\bar{x}} = 1.3068$

variance is determined to be insignificant), it follows that 92 percent is a relatively good intermediate range planning factor for peacetime flying program spares support.

To determine whether the level of spares degradation was constant from aircraft to aircraft and base to base, an analysis of variance was conducted. The hypothesis tested was that the degradation rates were equal for all eight bases in each of the twelve composite monthly periods ($\sigma = .01$).

$$\frac{\text{Mean Sum of Interaction}}{\text{Mean Sum of Error}} = \frac{.1389}{1.7077} = .0813 = F^*$$

$$F(.99,\ 7,\ 88) = 2.85$$

Since F* is less than F, it is clear that the sample composite means may be considered equal. Therefore, the peacetime flying program asset support factor of 92 percent has been shown to be relatively robust for planning purposes. The aircraft spares support model can therefore, be stated as:

$$y = 26.66 + Fx\ (.92) \qquad (3)$$

There are several weaknesses in this phase of the analysis. It was shown through statistical analysis that all the distributions of sample asset degradation rates were normal with differences in means which were insignificant. From this it may be inferred that there is no mid to long-range planning difference between the support levels of either the F-4 or C-130 aircraft at the foreign or domestic bases. This does not, however, mean that pipeline effects are negligible. As shown in the raw data, support degra-

dation for foreign based systems had wider variance from year-to-year and month-to-month. This may have been caused by a dearth to sate relationship which could indicate high rates of degradation due to delivery delays followed by overordering/stockpiling and oversupport. Also, despite the lack of significant difference in degradation rates, this does not necessarily infer that maintenance capability and capacity at foreign operated bases is comparable to existing U.S. foreign bases. Nor, is the condition of overcrowding at deployed bases considered. Overload at U.S. foreign bases is a particularly probable situation in the event of deployment. Lastly, the technical aspects of repair by host countries of our advanced technological systems are not addressed. This is a major weakness in the model which requires additional study.

Another critical caveat is the poor applicability of the peacetime support factor (i.e., 92 percent) to real time contingency situations. The support factor was not constant from year-to-year or month-to-month. Variations for discrete aircraft ranged up to 35 percent; however, over the four-year period, these fluctuations cancelled each other out. Hence, short-term support predictions based upon the 92 percent factor could be drastically inaccurate. Real time application of the support factor is not recommended.

Finally, only two aircraft, the F-4 and C-130, were considered in this analysis. Although they were the best examples available, they should not be construed to be overly representative of all Air Force weapon systems without further analysis.

## Conclusions

This paper has presented an aircraft weapon system spares support model for determining the number of days of contingency operations which would have a high probabability of not being compromised due to lack of required spares. It was postulated that contingency spares support is of paramount concern to Air Force readiness. Hence, the translation of current or predicted inventory conditions into meaningful measures of military capability is crucial to both operational and logistics planning. As pointed out, the Air Force currently has no management information system which can accurately assess spares support for deployed weapon systems. The model herein developed will serve as an interim planning structure and preliminary decision support model which provides mid to long-range (i.e., three to ten years) spares readiness assessment. Further research is underway to develop a more comprehensive model for real-time, short-range spares support assessments.

## References


1. Air Force Logistics Command. Computation of War Reserve Materials for Consumption-Type Items. AFLCR 57-18. Wright-Patterson AFB OH, 1974.

2. Bell, Chauncy F., and Robert M. Paulson. "Readiness Reporting: Concepts and Suggestions for Improvement." Unpublished working note No. WN-9623-PR, Rand Corporation, Santa Monica CA, September 1976.

3. Brooks, Robin B. S., and John Y. Lu. "War Reserve Spares Kits Supplemented by Normal Operating Assets." Unpublished research report No. RM-5725-PR, Rand Corporation, Santa Monica CA, September 1968.

4. Carlson, Captain Dennis A., USAF, and Captain Carlos M. Talbott, Jr., USAF. "The WRM Information System." Unpublished master's thesis. SLSR 15-76A, AFIT/SL, Wright-Patterson AFB OH, June 1976. LD37078A.

5. Freund, John E. Mathematical Statistics, Second Edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1971.

6. F/RF-4SM. Unpublished Minutes: "Minutes F/RF-4 Optimized WRSK Review." Ogden ALC/MMSSA, 12-21 July 1976.

7. Galliher, H. P., and R. C. Wilson. Aircraft Engines: Demand Forecasting and Inventory Redistribution. Aerospace Research Laboratory (AFSC), Wright-Patterson AFB OH, February 1975.

8. Muckstadt, J. A. "A Model for a Multi-Item, Multi-Echelon, Multi-Indenture Inventory System," Management Science, Vol. 20, No. 4 (December 1973), pp. 472-481.

9. Neter, John, William Wasserman, and G. A. Whitmore. Applied Statistics. Boston: Allyn and Bacon, Inc., 1978.

10. Rasmussen, Captain Robert K., USAF, and Captain William D. Stover, USAF. "A Simulation Model for Assessing WRSK Capability at Unit Level." Unpublished master's thesis. SLSR 4-78A, AFIT/SL, Wright-Patterson AFB OH, June 1978.

11. Recoverable Consumption Item Requirements System (D041). AFLCM 171-5. Wright-Patterson AFB OH: Government Printing Office, February 1973.

12. Standard Base Level Supply Procedures. Air Force Manual 67-1, Vol. 1, Part One. Washington: Government Printing Office, 1973.

13. Thomas, Major Jon R., and Major Norbert S. Nagy. "WRSK/BLSS Assessment Analysis." Unpublished research report, unnumbered, Air Force Logistics Command/XRXX, Wright-Patterson AFB OH, 1978.

14. U.S. Department of the Air Force. Recoverable Consumption Item Requirements System (D041). AFLCM 57-3, Change 1, Appendix 4, 19 June 1973.

15. ________. War Reserve Material. AFM 67-1, Vol. 1, Part 1, Amendment 5, Section F. Washington: Government Printing Office, 1976.

16. ________. War Reserve Materiel Policy. AFR 400-24. Washington: Government Printing Office, 1974.

17. Wilson, Ronald C. "Readiness and Spares Analysis," Logistics Spectrum, Fall 1977, pp. 10-13.

18. Winkler, Robert L. and William L. Hays. Statistics: Probability, Inference, and Decision, Second Edition. New York: Holt, Rinehart and Winston, 1975.